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ABSTRACT

This case study describes the effects of two innovations implemented in a college level Organic Chemistry II class for women. The teaching innovations were a student contract and affective strategies. The student contract was designed to ensure that students attended class and help sessions by guaranteeing a C to those that fulfilled the contract's guidelines. One of those guidelines was if students received a grade lower than a C on the first exam, they were required to get additional tutoring. Early in the course, feedback sheets indicated that many of the students in the course were anxious about chemistry as a subject and especially about the labs. Subsequently, several affective strategies were put in place to lower anxiety, improve confidence, and change attitudes towards chemistry. Data was collected about these two teaching innovations, the contract and affective strategies. Data was collected using surveys, evaluation forms, direct observations, faculty interviews, focus groups, and written feedback from students. One highlight is that the survey and interview data showed that the majority of students believed that the contract increased their chances of success in the course. The affective strategies including soliciting student feedback on their anxieties, implementing student suggestions for dealing with anxiety, and the instructor's confidence building strategies for her students. For example, the instructor asked students to say "I was successful" when completing their work in the lab, even though many of them resisted saying it. Based on the focus group interviews and post course survey data, saying "I'm successful" had a positive impact on most students' attitudes toward organic chemistry. Students felt more confident in carrying out science experiment by the end of the course and more relaxed when music was played in the lab. This evidence suggested that the affective strategies decreased anxiety and increased confidence for those women. In summary, according to a large percentage of students: (1) the course contract increased their chances for success in the course; (2) the affective strategies changed a large percentage of student's attitudes towards chemistry in a positive way. Taken together, the contract and affective strategies appeared to create a safety net for these women, making failing difficult and the chances for success more probable. (Contains 12 references.) (Author/YDS)

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Strategies Reducing Science Anxiety in Female University Chemistry Students

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Abstract

This case study describes the effects of two teaching innovations implemented in a college level Organic Chemistry II class for women. The teaching innovations were a student contract and affective strategies. The student contract was designed to ensure that students attended class and help sessions by guaranteeing a C to those that fulfilled the contractís guidelines. One of those guidelines was if students received a grade lower than a C on the first exam, they were required to get additional tutoring. Early in the course, feedback sheets indicated that many of the students in the course were anxious about chemistry as a subject and especially about the labs. Subsequently, several affective strategies were put in place to lower anxiety, improve confidence, and change attitudes towards chemistry. Data was collected about these two teaching innovations, the contract and affective strategies.

Data was collected using surveys, evaluation forms, direct observations, faculty interviews, focus groups, and written feedback from the students. One highlight is that the survey and interview data showed that the majority of students believed that the contract increased their chances of success in the course. The affective strategies included soliciting student feedback on their anxieties, implementing student suggestions for dealing with anxiety, and the instructorís confidence building strategies for her students. For example, the instructor asked students to say "I was successful" when completing their work in the lab, even though many of them resisted saying it. Based on the focus group interviews and post course survey data, saying "Iím successful" had a positive impact on most studentsí attitudes towards organic chemistry. Students felt more confident in carrying out science experiments by the end of the course and more relaxed when music was played in the lab. This evidence suggested that the affective strategies decreased anxiety and increased confidence for these women. In summary, according to a large percentage of students: (1) the course contract increased their chances for success in the course; (2) the affective strategies changed a large percentage of studentsí attitudes towards chemistry in a positive way. Taken together, the contract and affective strategies appeared to create a safety net for these women, making failing difficult and the chances for success more probable.

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Strategies Reducing Science Anxiety in Female University Chemistry Students

With increased awareness that female high school students feel less confident than male students about their abilities and likelihood of success in physical science (Eccles, 1998), and that "female students have less positive attitudes towards science than male students during the middle school and high school years" (Catsambis, 1995), new strategies to include women in science have become evident in todayís science classroom. Despite current efforts to support women who are studying science, the gap between the numbers of men and women who earned a degree in physical sciences still rose between 1982 and 1994 (Bae and Smith, 1996). Female-friendly strategies that are popular but remain focused on re-engineered content and evaluation do not appear to be wholly effective in changing the landscape of physical science to include women. This study describes some different strategies to support women in physical sciences.

Currently, "two-thirds of the top-producing institutions of women doctorates in physical sciences are liberal arts colleges" (Sharpe, 1995). Mount Holyoke College, a liberal arts college for women, boasts the highest origin of women with PhDs in chemistry than any other college or university in the United States (Rossiter, 1995). It is apparent that Mount Holyoke College is doing something right to encourage women in science. Our goal in conducting this case study was to uncover the strategies being used by one of their chemistry departmentís most innovative instructors.

A. TEACHING STRATEGIES DESIGNED TO FACILITATE LEARNING AND CHANGE AN ORGANIC CHEMISTRY COURSE FOR WOMEN

In the Spring of 1998, Professor Sheila Browne attempted several teaching strategies in order to improve studentsí achievement in organic chemistry. Professor Browne placed students into learning groups comprised of three to five students. Learning groups were used for homework, during class, and pairs were used in the lab. In order to motivate students to complete their homework assignments regularly, they were encouraged to sign an optional "contract" in the first week of classes committing them to these activities. Professor Browne also used "affective" strategies designed to change the self-confidence of her students. This paper will focus on the last two innovations, the contract and affective strategies. A detailed description of the group strategies is in "A Course Designed to Build a Learning Community in an Organic Chemistry Class for Women" (S. Khan and J. Clement, 1999).

B. SETTING

(i) The course

After completing the prerequisite, a one semester Organic Chemistry I course, seventy six students enrolled in a one semester, senior Organic Chemistry II course, called Chemistry 302. Professor Browne taught all three components of Chemistry 302: the class, the lab, and the help sessions. Students attended two 75 minute classes, a 4 hour lab, and a 50 minute help session, also known as the "4th hour", every week, to complete the 4 credit course.

ii) The students

The students came from a variety of backgrounds. Academically, they ranged from those who had not taken chemistry for 2 years, to those that came directly from the prerequisite course, Organic Chemistry I. The instructor estimated that of the 76 predominantly female students, about 20 were minorities and 5 were older or non-traditional students.

iii) The instructor

The instructor of Organic Chemistry II was Professor Sheila Browne, a recipient of the 1998 Presidential Award for Excellence in Science, Mathematics and Engineering Mentoring. In an interview with Professor Browne, she explained that her motivation for teaching was to create a "better atmosphere for women and minorities in science. ... One way I see of creating that is for them to be confident." Professor Browne described her attitude as "everyone there can do it. They can do it well."

D. DATA COLLECTION

The data was collected from two faculty interviews, three classroom observations, two lab observations, three sets of feedback sheets, one analysis of course evaluation forms, one in depth interview with two students, one large group survey, one focus group interview with six students and one electronic survey from two minority students and a student describing herself as a "future teacher".

Data collection initially began with a class observation and a faculty interview. Two interviewers, Samia Khan and John Clement, conducted and tape recorded the interview in order to document the instructorís goals and intended teaching strategies for the course.

Additional early data came from three sets of feedback sheets for our analysis. Feedback sheets were writing exercises meant to expose studentís perceptions about various aspects of the course. In the first set of feedback sheets, students wrote about themselves and their personal strengths and weaknesses. In the second set of feedback sheets, students wrote about their feelings on the course in general, and in the third set, students wrote about homework groups

Two student interviews were also conducted. In the first interview, two students completed a written questionnaire before an in-depth discussion about the course. Several issues about the course emerged from this in-depth discussion. Towards the end of the course, the issues derived from the faculty interview, feedback sheets, and the in-depth interview were presented as a survey to a larger group of students from the same class. The large group, Likert-response survey was administered to fifty eight students during the 4th hour. After the results were tabulated, a focus group of six students was assembled in a second interview to elaborate on the findings from the large group survey. The notes and quotations taken from the focus group were later verified with students by electronic mail. At the same time, an electronic survey about minority and teaching issues was completed by three respondents. After the course was complete, an exit interview with the instructor was video taped, and 62 final course evaluations from students were analyzed.

E. THE CHEMISTRY CONTRACT

Professor Browne remembered from her past teaching experiences that as soon as students "start doing poorly, they begin to fade and not attend class or do the homework." Professor Browne believed that completing assigned work regularly would prevent all students from the downward spiral of getting behind in the course, attaining poor grades, and becoming discouraged, all which she referred to as "fading". In order to increase the likelihood that such assigned work would be completed regularly, the instructor implemented a "chemistry contract".

i) Contract guidelines

Professor Browne believed that attendance was one of the most important factors in order for students to keep up with the course: "as soon as [students] start doing

poorly, they stop coming to lecture. It happens more to the minority students [in this course] than the mainstream. Gotta find a way that theyíre going to stay there--and the contract keeps them there." Because the instructor felt that coming to class was essential for student learning, the contract only permitted two missed classes throughout the term for all students. All homework was to be turned in on time with only two late assignments allowed without penalty. Attending class and doing homework on time were Professor Browneís strongest recommendations for her students.

A second purpose of the contract was to provide repair mechanisms for students if they made mistakes. Students had a redo option which gave them the opportunity to rewrite incorrect homework or redo lab reports. Also as part of the contract, students were required to attend "4th hours". 4th hours were literally the fourth hour of class time, where no curriculum was required to be covered. Instead, the fourth hour was designed to address studentsí problems with the course or laboratories. Finally, if a student received less than a C on the first exam, they were obligated to seek additional tutoring from volunteer tutors in the class. The redo option, 4th hours, and the supplemental tutoring acted as repair mechanisms that were designed to help students recover from their errors.

The final part of the contract was to offer a grade guarantee: if students met all of these contractual obligations, they were guaranteed an overall grade of C in Organic Chemistry II. The contract guidelines, repair mechanisms, and grade guarantee were all meant to make failing difficult and to increase the studentsí chances for success. A copy of the contract appears on the next page.

ii) Unexpected responses to the contract

Professor Browne recalled, "The contract scared me to death the first time. I figured that theyíre just going to sit back and theyíre not going to do anything..."; however, some unexpected student responses did emerge with the introduction of the contract. Apparently, students felt "relieved" with the contractís guarantee. One focus group student revealed, "To come in here and have that weight lifted that you are not going to fail in this class. You canít do anything to fail in this class. So now letís see what you can do." Another student felt that "[t]he contract made all the difference for me; I could stop worrying and actually start listening to what she [the instructor] was saying. It took the pressure off and helped to make me less anxious overall. The requirements for making a C [were] really not very strenuous." Overcoming this fear of failing was a common theme in the studentsí comments. Another focus group student said, "[the contract] really alleviate[d] a lot of the pressure, and you can better concentrate on learning (as opposed to just passing)." The majority of students shared the feeling that the contract provided relief, and overcame the fear of failing in order to focus on learning instead of passing. In the large group survey, 55% felt that the contract alleviated the pressure of ëjust passingí so that students could concentrate more on learning. [Ref: 3. The contract alleviated the pressure of ëjust passingí so that I could concentrate more on learning. A) 15/58 or 26% B) 17/58 or 29% C) 18/58 or 31% D) 4/58 or 7% E) 4/58 or 7%]. The grade guarantee in the chemistry contract appeared to give many chemistry students a sense of relief to the point where some overcame their fear of failing and could concentrate more on trying to learn.

CONTRACT

for Organic Chemistry 302

Spring, 1998

Organic Chemistry is an exciting but challenging class. The keys to surviving and

even thriving are the points covered here: attending class and working through the homework in a thoughtful way. (And of course studying!) Adherence to the terms of this contract guarantees you a C in the class. However, if you follow this contract you will probably do much better.

Homework

Homework will be assigned weekly and is due the following Friday. Late homework is due the following Monday for half credit. (*Two late assignments allowed without penalty.*) Homework will not be graded after that time. Your work will be graded and returned early in the week. Homework can be rewritten if you are unsatisfied

with your mark, but must be handed in on Friday of the week it was returned. Homework deemed to be an insufficient effort by the grader will be considered late.

I, , the undersigned do hereby accept the terms of the CONTRACT for Organic Chemistry 302. I acknowledge that I have read and understood the requirements for fulfilling the contract.

I will attend every scheduled class

2 missed classes allowed

I will attend each 4th hour

2 missed 4th hours allowed

I will turn in all homework on time

2 late assignments allowed without penalty

I will get additional tutoring if I receive a grade

lower than a C on the 1st exam.

Signature

"Do or do not. There is no try."

- Yoda, Return of the Jedi

"If you believe in yourself , you are already there."

- Dr. Sheila Browne

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iii) Keeping up with the course

The contract required students to attend every class and turn in all their homework in on time. Two students comments from the focus groups were, "I really like the contract idea, it makes me come to class and stick with the material", and "...just by making myself be there every day, I really do pick up a lot more than in other classes." At times, Professor Browne had a difficulty keeping track of attendance. She finally decided to send attendance sheets around the class in order to verify corrections to the attendance record. One student believed that "some people cheated when Sheila asked people to make corrections to the attendance sheets." Thus, it appears that some additional form of accountability would need to be built in to track attendance fully. Overall, however, the contract seemed to make students more aware of how important attendance was for success in the course. The contract also reemphasized the importance of doing homework on time. One student recognized this and believed that the instructor "was not going to ...let us fail or falter to the point of sacrificing your grade:...or even more importantly, sacrificing your knowledge...".

iv) Repair mechanisms .

The redo option, 4th hour and additional tutoring were built in to the contract as repair mechanisms to prevent "fading". Despite all of these repair mechanisms, the contract could not ésaveí everybody. Professor Browne had pinpointed 5 students who were not passing the course. She explained, "I was having trouble determining whether they were in the contract or not. So finally had to send a note through, *ëare you in the contract or not?í* ; and it turns out that the people who are doing poorly on things were really worrying me, because I was thinking the course wasnít working. [But they] had slipped out of the contract. They hadnít done homework and they hadnít been showing up." Those particular students chose to leave the contract and receive their grade accordingly.

Most students, however, did take advantage of at least one of the contractís opportunities for help. The redo option proved to have an impact on the greatest number of students, with 82% of the students feeling that the redo option improved their understanding. [Ref. 31. The redo option for assignments, reports, and tests improves my understanding of chemistry. A) 32/58 or 55% B) 19/58 or 32% C) 7/58 or 12% D) 0/58 or 0% E) 0/58 or 0%]. Sixty three percent of the class used 4th hours to help solve chemistry problems [Ref. 35. I have used the 4th hour to help me solve chemistry problems. A) 14 /58 or 24% B) 23/58 or 39% C) 14/58 or 25% D) 4/58 or 6% E) 3/58 or 5%], and 18% of the surveyed students sought the use of tutors [Ref.: 36. I have used the tutors to help me solve problems. A) 4/58 or 6% B) 8/58 or 12% C) 14/58 or 24% D) 14/58 or 24% E) 18/58 or 31%]. Redoing assignments, the 4th hours, and tutoring collectively served as repair mechanisms by providing extra support for learning to recover from errors. The repair mechanisms, along with the grade guarantee and attendance requirements were clearly intended to help prevent students from failing.

v) Summary of the contract

Students believed the grade guarantee alleviated the pressure of passing so that they could concentrate on learning. The attendance and homework requirements; the redo option, 4th hours, and tutoring all made failing the course difficult. The majority of the surveyed respondents believed that the contract improved their likelihood of being successful in the course. [Ref. 10. The contract increases my chances of success in this course. A) 16/58 or 27% B) 17/58 or 29% C) 15/58 or 26% D) 5/58 or 9% E) 5/58 or 9%].

In a study of a college chemistry class that also assessed the use of performance contracts compared to a control group, Dougherty (1997) found that "grade obsession often results in exam anxiety and decreased performance. It also decreases retention...The provision of a grade/study-performance contract de-emphasizes grades." Doughertyís study showed that, compared to the chemistry class with the contract, the noncontract lectureís attendance dropped by almost 50% by the end of the term. Doughertyís data also suggests that grade/study-performance contracts can contribute to both student learning and retention.

Our study leads us to believe that contractual obligations to attend class and do homework on time allowed students to keep up with the course and consequently, make failing the course difficult and the chances for success more probable. The contractís grade guarantee appeared to alleviate the pressure of passing the course and overcame that fear of failing that restricts success. Two focus group students summed up their opinions of the contract: "And I think, for me, just to be at this point in the class and know that you are not going to fail, you are going to pass -- that you are going to learn and you are going to do more than just pass -- is success. Not having that overwhelming feeling of ëwhat if I failed this classí. To me thatís success." The second student wrote that the contract "was the best thing thatís happened in my chemistry "career" at MHC".

F. AFFECTIVE STRATEGIES

Sheila Tobias remarked that "of the many myths about science...., perhaps the most pervasive is that the learning and doing of science...is purely a matter of the mind (Mallow, 1986). Both problem solving strategies and mental contents in general have been shown to be affected by emotions (Mandler, 1989), and "achievement and persistence in science have been linked to studentsí attitudes (Hanson, 1996). Even though over the last two decades, gender differences in verbal, quantitative, and spatial skills have declined essentially to zero, lower confidence towards science is found disproportionately in females (Linn, 1993). Anxiety towards science can intrude on the ability and willingness to learn. "Females expressed greater science study test anxiety and observer anxiety, less confidence in their scientific and problem solving abilities, and less frequent participation in curricular and extracurricular science activities." (Matyas, 1984). Mallow of the Science Anxiety Clinic in Chicago recommends that "a good deal of the fight against science anxiety involves ...recognizing when you are feeling anxious, tuning in to the things you are telling yourself, the "negative self-statements" that cause the anxiety; examining these statements for the irrational beliefs behind them; and finally, producing "coping statements"--new self-statements that counter your anxiety and allow you to function better in science-related situations." (Mallow, 1986).

i) Feedback sheets as a detection mechanism

For Professor Browne, feedback sheets were instrumental in detecting difficulties students were having in the course. Professor Browne described in an interview that, "What I would do is I would put on the board, ëHow are you doing? Howís the environment in the class, [and] howís the environment in the lab? What are you scared about? What changes would you make? What suggestions do you have?í" The feedback sheets were instrumental in pinpointing the sources of the anxiety.

The early feedback sheets revealed that the students enrolled in organic chemistry had significant anxiety about the course, especially the lab. Consequently, Professor Browne implemented three new affective strategies designed to lower student anxiety and increase their confidence. Music was played in the lab, the instructor and the students were involved in overcoming self-identified, personal fears, and students were prohibited from openly putting themselves down when talking. These three strategies were labeled affective because they dealt with studentsí emotions and were aimed at changing studentsí self-perception and attitudes towards chemistry. Throughout the course, Professor Browne used feedback sheets as a way to detect and uncover anxieties about aspects of the course.

ii) Anxiety about organic chemistry

Out of 71 students who wrote feedback sheets, 26 (36%) students mentioned feeling anxious in some way about organic chemistry. Comments like, "I was terrified about performing experiments, specifically not knowing the equipment to use", and, "[a]t the beginning of the semester, I tried to avoid opening my book because I was scared to death of starting chemistry for another semester" represented significant anxiety about the course to us. In fact, 67% of the respondents in the large group survey expressed some anxiety about chemistry even before entering the course [Ref. 1. I was anxious about chemistry before starting this course. A) 22/58 or 38% B) 17/58 or 29% C) 8/58 or 14% D) 9/58 or 16% E) 2/58 or 3%], and 60% of the respondents indicated that this anxiety was greater than any other course [Ref. 2. I was anxious about chemistry more than my other courses. A) 18/58 or 31% B) 17/58 or 29% C) 12/58 or 20% D) 7/58 or 12% E) 4/58 or 7%]. Thus, a very large percentage of the students entered the course with a significant degree of anxiety.

In response to an early set of feedback sheets, Professor Browne raised the anxiety issue in class and asked for suggestions on what to do about it. Students came up with several suggestions, and Professor Browne implemented deliberate changes to the lab and her interactions with students as a result of these suggestions: "There are ways of working around the anxiety that gives them the freedom to learn. And when they have freedom, they get a lot more confident." One of the studentsí ideas was to play music in the labs.

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iii) Effects of playing music in the lab

Because the labs were the major source of anxiety for the chemistry students, they suggested that music be played during labs in order to relax them. Students brought their own music to the lab, with some restrictions that were outlined by the instructor. Out of 71 students who wrote feedback sheets, 21 (29%) of them openly commented on the music. Their comments were all positive about the music, such as, "I feel more relaxed in the labs when we have music playing", and "[Music] really makes a difference because it doesnít feel like itís four hours that you spend in there." A focus group member commented that the labs this year were, "Very different. Less stress, therefore more opportunity for learning and thinking. I feel more at ease...in this lab. The music helps." With the music, a student described the "[a]tmosphere [as being] so comfortable and relaxed, that so much of that uptight feeling is gone." Sixty five percent of the respondents felt more relaxed with music in the lab. [Ref. 26. I feel more relaxed in the labs when we have music playing. A) 30/58 or 51% B) 8/58 or 14% C) 19/58 or 32% D) 1/58 or 1% E) 0/58 or 0%]. Thus music appeared to be effective in lowering anxiety levels in the lab.

For students, a lower anxiety level translated into less breakages and more enjoyment in the lab. A focus group student commented, "The impact [of the music] is best demonstrated by the fact that there have been zero accidents/breakage in our lab and zero injuries. Last yearís lab was so stressful that 2-3 students experienced acid burns (minor) and equipment broke all the time." Professor Browne corroborated that the breakage rate went down considerably. One student compared the lab she transferred to which did not have music: "We donít have music and I feel its absence. I think comfort has decreased, and confusion has increased." The music appeared to relax students and lower anxiety levels to the point where they may have contributed to the decrease in the number of accidents with the equipment. A lower anxiety level may have also brought students to the point where they were enjoying the lab more often than in previous science labs. [Ref. 24. I enjoy the lab more now than in past science courses. A) 34/58 or 58% B) 13/58 or 22% C) 7/58 or 12% D) 2/58 or 3% E) 2/58 or 3%].

iv) Studentsí fears

Not only were the feedback sheets used to detect anxieties about aspects of the course, but they also uncovered studentsí perceptions of their weaknesses. In one set of feedback sheets, the instructor asked students to share personal goals, strengths, and weaknesses with the instructor. Students openly revealed their weaknesses in the feedback sheets and that gave Professor Browne an opportunity to help her students overcome them. Some of the written descriptions of perceptions about school, ability and chemistry from the feedback sheets included:

"I have always come into every Chemistry class with a bit of hesitation and fear. I look back now and know that this fear hindered me from doing the best that I could do."

"I previously stated that organic chemistry terrifies me. ...No other subject has succeeded at confusing me to the point of tears, even after many hours of intense study...".

"I am completely frightened about Organic Chemistry and that, I believe, might be my greatest weakness. Last spring, I took Organic I, and I struggled to the point that it affected my other classes... One of my weaknesses is that I have a tendency to work alone because I sometimes feel like Iím not smart enough. I fear that my peers will pick up on that and not want to work with me anyway. This semester, I will try and work with others and let you and my team members know what I donít understand. I have to learn how to seek help rather than suffer all alone, accomplishing nothing at the end, but a sense of hopelessness." The feedback sheets gave the instructor a unique window into studentsí real fears and personal weaknesses.

Once these fears were revealed, Professor Browne worked with her students to help overcome them. In a focus group interview, one minority student described how Professor Browne helped overcome her specific fear of asking questions: "Professor Browne asked, ëWhat is it that kept you getting where you wanted to be...?í ... [f]or me it was to ask questions. And for me she said, ëYour requirement is in the next two lectures, I need for you to raise your hand and ask something, because you are not stupid, ask questions!" The student recalled, "And I did, and it worked. You know the world didnít come to a screeching halt and nobody turned around and said, stupid....[t]hat didnít happen!... I feel confidence that I didnít have before I started this class, and...now Iím not as reticent to ask a question in a class. The issues of self-esteem are very, very powerful and carry a lot of weight." Professor Browne remembered this minority student: "[s]he turned into a very different person because every time she asked a question,...Iíd say, ëThatís a really valuable question to the rest of the class.í ...And afterwards, people would actually go and say [to her], ëIím glad you asked that questioní ." The feedback sheets gave Professor Browne specific insight and unique opportunities to help students overcome their weaknesses.

v) Saying "Iím Successful"

One of the difficulties Professor Browne confronted from her own personal experience and were reiterated in the feedback sheets from her students was that many of the women in the course, especially minorities, had a difficult time saying they were successful. She made a practice of talking with students in the lab about their yields and results. When students were having difficulty recognizing their successful results, Professor Browne would make them repeat that they were successful. A focus group student who was a member of a minority group recalled, "Initially, when she would say things such as, ëYou are successful; you are intelligent, I almost thought it was silly. ...But there is something about hearing it over and over... And you would argue it.... [S]he would come around and say, ëhow did it go?í And weíll show her and sheís say, ëOh, that looks great" And youíre like ëOKí. She goes, "Say that it looks great." And weíll go, "Yeah, it looked great." But then after a couple of weeks [of saying Iím successful] youíre like, "I kicked butt!!" She does it so often and it makes so much difference. She has said so many times ëYou guys can do this, you guys know more than you think you do.í All that positive feedback ...I am amazed at the impact that has had." Seventy eight percent of surveyed students said that saying "Iím successful" had a positive impact on their attitudes towards chemistry and the lab. [Ref. 38. Saying "Iím successful" has a positive impact on my attitude towards chemistry and the lab. A) 23/59 or 40% B) 22/58 or 38% C) 8/58 or 12% D) 2/58 or 3% E) 3/58 or 4%].

Professor Browne noted that, "They are always surprised when they can do something and so we try to make it less of a surprise and more of an expectation." From her perspective, she remembered the students undergoing a transition: "[b]y the end, she was confident in lab. We just wouldnít let it go. I had them all say, as they left, I asked them, ëDid you have a successful lab?í and the first couple, three times, it was like pulling teeth. They just could not say, ëIt worked! I had a successful lab. I finished. I got my product.í And after a while they start seeing themselves as being successful in lab." Seventy one percent of the large group survey now felt more confident carrying out science experiments [Ref. 28. I feel more confident carrying out science experiments. A) 18/58 or 31% B) 23/58 or 40% C) 12/58 or 20% D) 4/58 or 9% E) 1/58 or 1%.]. One student added, "There was a sense of closure since we were asked if we were successful when we left."

The student comments below depict the impact of saying "Iím successful" and other strategies on studentsí attitudes and beliefs in their ability:

"I feel confidence that I didnít have before I started this class. And she really ...makes me feel that she...believes in me ... Itís nice to feel that some one really believes in you and youíre abilities and youíre goals."

"Yes, and this course gives me more confidence about pursuing such a goal [referring to becoming a teacher].... Prof. Browne helps us feel important, intelligent and more confident."

"I have been able to raise my expectations about my own performance."

"This course has redeemed me. I was very nearly at the brink of giving up on science all together. My anxieties were crippling me."

"I have been able to succeed in science, whereas a few other Hispanic women who have come from the similar upbringings are not doing well right now. I want to help them out so that they do succeed, so I encourage them and help them with their work because I explain the material differently from the book."

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"Academically, I can succeed at whatever I choose. She has helped me remember how competent I am because for a while I had forgotten."

vi) Summary: Affective strategies in concert with the other innovations changed student anxiety, confidence, and attitudes towards chemistry

a. Lower anxiety changed studentsí attitudes about the course

A significant level of anxiety about organic chemistry existed even before the course started. The evidence leads us to believe that the contract and music in the lab played a role in lowering anxiety for students. Unexpectedly, the chemistry contractís guarantee alleviated many studentsí fears about failure and pressures about passing this traditionally difficult course. Many students felt that alleviating this pressure gave them the freedom to learn. Consequently, most students felt that the contract increased their chances for success in the course.

Professor Browne learned about "crippling anxieties" when she asked students to share their goals and reveal their weaknesses in feedback sheets. Once she learned that a major source of anxiety was centered around the lab, she solicited ideas for intervention. Several affective strategies were born out of open acknowledgment and discussions with her students. In an effort to create a relaxing atmosphere, music was allowed in the lab. Surprisingly, students said that music had a significant impact on lowering anxiety in the lab, and most students stated that they enjoy the lab more now than they have in past science courses.

b. Improving confidence changes studentsí attitudes about the course

Two teaching strategies appeared to have major impact on improving most studentsí confidence: the cooperative groups and saying ëIím successfulí. The groups are mentioned here because they may have contributed to the overall effect of lowering anxiety and improving confidence. More specifically, being in cooperative groups, whether they were in the lab, class, or at home, appeared to give students the confidence to ask questions. The majority of the women surveyed agreed that more students speak out in this class than in other science classes. [Ref. 11. More people spoke out in this class than other science classes Iíve seen. A) 11/58 or 19% B) 16/58 or 27% C) 21/58 or 36% D) 6/58 or 10% E) 4/58 or 6%]. "Speaking out" was an indicator that students felt more comfortable asking questions in front of the large group. This comfort level with speaking out may have been improved because students felt more reassured and safe with the support of a group. In fact, the majority of students responded positively to the statement, "I feel safe in acknowledging my mistakes in this course." [Ref. 32. I feel safe in acknowledging my mistakes in this course. A) 17/58 or 29% b) b 25/58 or 43% C) 13/58 or 22% D) 2/58 or 3% E) 19/59 or 32%]. The groups are mentioned here because they may have contributed to the overall effect of lowering anxiety with the safety in numbers phenomena. For a more detailed review of the groups, see S. Khan and J. Clement (1999).

Saying ëIím successfulí appeared to have an impact on studentsí self-perception of their abilities in the lab. Many women appeared to have difficulty recognizing their successes, especially in the lab. Professor Browne prohibited students from putting themselves down, and in turn, she encouraged them to recognize their successes by saying it out loud. When students began to say they were successful, it appeared to change their attitude about their ability in organic chemistry and science.

G. PROVIDING A SAFETY NET

In this section we propose a larger scale hypothesis for how these innovations may have worked in concert to form a "safety net" for these students. We have evidence that various strategies acted to lower anxiety and improve confidence. We think it is very plausible that the contract and affective strategies acted as a "safety net" in the sense that they "saved" some students who otherwise would have failed or dropped out of the course. Students who sense they are in danger of failing often lack confidence and suffer from anxiety about failing, and this in turn increases their chances of failing. In this way a vicious circle is set up, as shown in Figure 1, which can cause such a student to spiral downward, stop trying, and, in the words of the instructor, "fade" out of the course. This is a positive feedback system that can be very difficult to arrest.

Higher Anxiety, Lower

Less Confidence Performance

Figure 1

The above strategies acted as a safety net to prevent or arrest such downward spirals because they attacked both sides of the vicious circle at once-- they reduced anxiety, increased confidence, and provided repair mechanisms when students were making errors or not performing well to raise chances of better performance. This is a sense in which the combination of strategies is "systemic". We believe that a safety net of this kind has an extremely important role in making failing difficult and increasing the chances of success for women in physical science, as it appears to have done in this chemistry class.

II. CONCLUSION

In conclusion, the evaluators found three aspects of the data from this course to be particularly unusual:

- That so many of the women in this course expressed feeling anxious about entering their third chemistry course;
- That the instructor implemented motivational and affective strategies and that these appeared to have a measurable effect on lowering anxiety and increasing the womenís confidence in their ability to deal with an advanced chemistry course;
- That the contract and affective strategies worked in concert to create a "safety net" in which students could concentrate more on learning and less on feeling inadequate or anxious. Such safety nets may be very important for preventing many scientifically talented women from dropping out of science.

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